LOCA/LOFA Analyses for Blanket and Shield Only Regions – LiPb/FS/He System

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LOCA/LOFA Analysis Update

1. Results from LOCA/LOFA models with the gap between blanket and shield removed. The interface has been replaced with a perfect contact condition.

2. Maximum temperatures for LOCA and LOFA as a function of $\bar{\Gamma}$ are presented to help establish thermal operating limits.

3. Preliminary results for the shield only regions will be discussed.
ANSYS FE Model and Boundary Conditions for Thermal Analyses

- Adiabatic boundary at back of vacuum vessel.
- Model is axisymmetric about plasma centerline and symmetric on sides. Gap between blanket and shield replaced with perfect contact condition.
- Emissivity of 0.3 assumed across vacuum gap and vacated cooling channels.
- All analyses assume there is no helium in channels.
Thermal Results LOFA for LiPb and Water and LOCA for He

- Model modified to remove vacuum gap between blanket and shield to agree with current configuration.
- Maximum temperature is 14 C lower with gap removed and perfect contact assumed.

1 cm Gap Between Blanket and Shield
Maximum temperature – 715 C

Perfect Contact Between Blanket and Shield
Maximum temperature – 701 C
Thermal Response for LOCA in Blanket/Shield and LOFA in Vacuum Vessel

- Maximum temperature is 23 C lower with ideal contact between blanket and shield compared to 1 cm vacuum gap case.
- Maximum temperature is higher for LOCA (706 C) compared to LOFA (701 C).

1 cm Gap Between Blanket and Shield
Maximum temperature – 729 C

Perfect Contact Between Blanket and Shield
Maximum temperature – 706 C
Thermal Results for Fusion Power Scaled by 1.5

- Maximum temperatures for ratio $\Gamma=1.5$ exceed 740°C FS limit.
- Again, maximum temperature is higher for LOCA than LOFA.
Variation of Maximum Temperature with $\bar{\Gamma}$

- 740 C FS limit exceeded for $\bar{\Gamma} > 2.3$ MW/m$^2$ with current configuration
Shield Only Zone Analysis

FEA Model
Assumes shield only region about entire radius (conservative temperature estimate)
LOCA Thermal Results for Shield Only Region

- Maximum temperature of 1427 C occurs after 24 hours.
- Natural convection to water in vacuum vessel included.
- Emissivity of 0.3 assumed for radiation in vacuum gap.
- Initial temperatures of 500 C assumed for 1st wall and WC, 450 C for cooling channels, and 100 C for vacuum vessel.
Temperature Distribution at t = 1Day

- Large gradient occurs across vacuum gap ($\varepsilon=0.3$ assumed).
- Temperature gradients across Shield II and gap confirmed with hand calculations.

![Graph showing temperature distribution](image_url)
Variation of Maximum Shield Temperature with Gap Emissivity

- Increasing emissivity across can not reduce temperatures to acceptable levels.
- 3-D analysis with transition regions are required to properly analyze region.
- Passive system may be required to achieve temperature limits.
Summary and Future Plans

1. Removal of the gap between the vacuum and shield reduced the maximum temperatures by 14-23°C for LOCA/LOFA cases.

2. $\bar{\Gamma}$ should not exceed 2.34 MW/m² to keep blanket FS temperature below 740°C during LOCA/LOFA for current configuration.

3. Blanket and shield model is to be updated to latest configuration and temperature limits/design sensitivity will be further evaluated.

4. Shield only region temperatures greatly exceed limits. Increasing emissivity does not solve problem. Passive safety system may be needed.

5. A full 3-D model of shield only and transition regions will be developed to further investigate this problem.